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Impact of nonhomogeneous nanofluid model on transient mixed convection in a double lid-driven wavy cavity involving solid circular cylinder

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Abstract

Heat transfer enhancement in engineering systems can be reached using nanofluids. Very often, technical devices are chambers with moving borders of a flat or a wavy shape having internal heat-conducting blocks. Therefore, the present study is devoted to study computationally the problem of time-dependent heat transfer of alumina-water nanoliquid within a differentially heated chamber with isothermal moving vertical walls and adiabatic horizontal ones under the impact of an inner solid cylinder. The upper wall of the chamber is assumed to have a wavy shape. Basic equations written in non-dimensional primitive variables using the two-component nonhomogeneous equilibrium model for transport phenomena in nanofluids incorporating the effects of Brownian diffusion and thermophoresis with Corcione empirical correlations for the viscosity and thermal conductivity combined with heat conduction equation for the centered solid cylinder has been resolved by the Galerkin finite-element method. The influences of the dimensionless time ($0 \leq \tau \leq 120$), Reynolds number (Re=10 and 100), Richardson number ($0.01 \leq Ri \leq 100$), constant moving parameter [($\lambda l=1, \lambda r=-1$), ($\lambda l=1, \lambda r=1$), ($\lambda l=-1, \lambda r=1$), ($\lambda l=-1, \lambda r=-1$)], nanoparticle volume fraction ($0 \leq \phi \leq 0.04$), number of undulations ($0 \leq N \leq 4$) and the dimensionless radius of solid cylinder ($0.05 \leq S \leq 0.25$) on the isolines of stream function, temperature and nanoparticles concentrations, as well as the local and average Nusselt numbers have been investigated. It has been found that a rise of the average Nusselt number at the hot wall depends on the moving parameter and the thermal transmission intensity diminishes with the undulations number and the inner solid cylinder diameter. At the same time, the wavy shape of the border, the characteristics of internal cylinder and the properties of nanofluid are very good control parameters for the heat transfer rate and the fluid flow rate. © 2018 Elsevier Ltd

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